EFFECTS OF DISTURBANCE ON KILLER WHALES

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- Introduction
  - Sources of Disturbance
  - Mechanisms of Impact
- Methods
  - Observation
  - Experimentation
- Results
  - Behavior States
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  - Movement Patterns
  - Effects of mid-frequency sonar
- Discussion
  - Zones of Influence
  - Effects on foraging efficiency
  - Population Scale Effects
  - Management Options

Sources of Disturbance

- Explosives
- Airguns
- Mid-Frequency Sonar
- LFA Sonar
- Acoustic Tomography
- Industrial
- Acoustic Harassment/Deterrent Devices
- Tourist Vessels
- Commercial Fishing
- Freight Traffic
- Aircraft
- Biological
- Physical

Mechanisms

- Collisions with vessels
- Pollution
- Noise
- Physical presence
- Stress

Noise Impact Mechanisms

- Masking
- Threshold Shifts
- Displacement
  - Excess Energy Expenditure
  - Impaired Foraging Efficiency
- Behavioral Changes
- Effects on Prey

Observations of focal whales

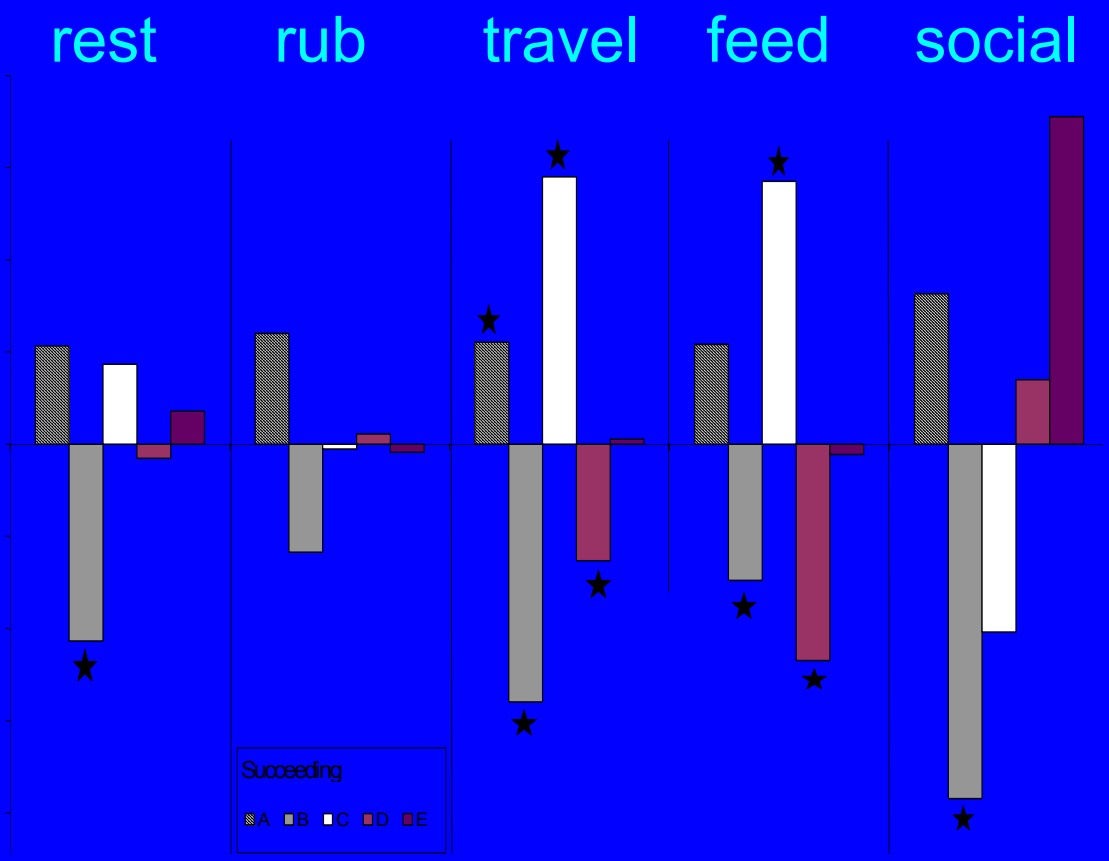
- land-based
- theodolite (objective and repeatable)
- measure behavior with no boats around
- compare to behavior with different levels of boat activity (number, proximity, operating practices)

Experiments on focal whales

- observe a whale for 20min without boats
- approach focal with experimental boat
- parallel the whale at 100m for 20min
- compare pre-exposure, exposure, and post-exposure data

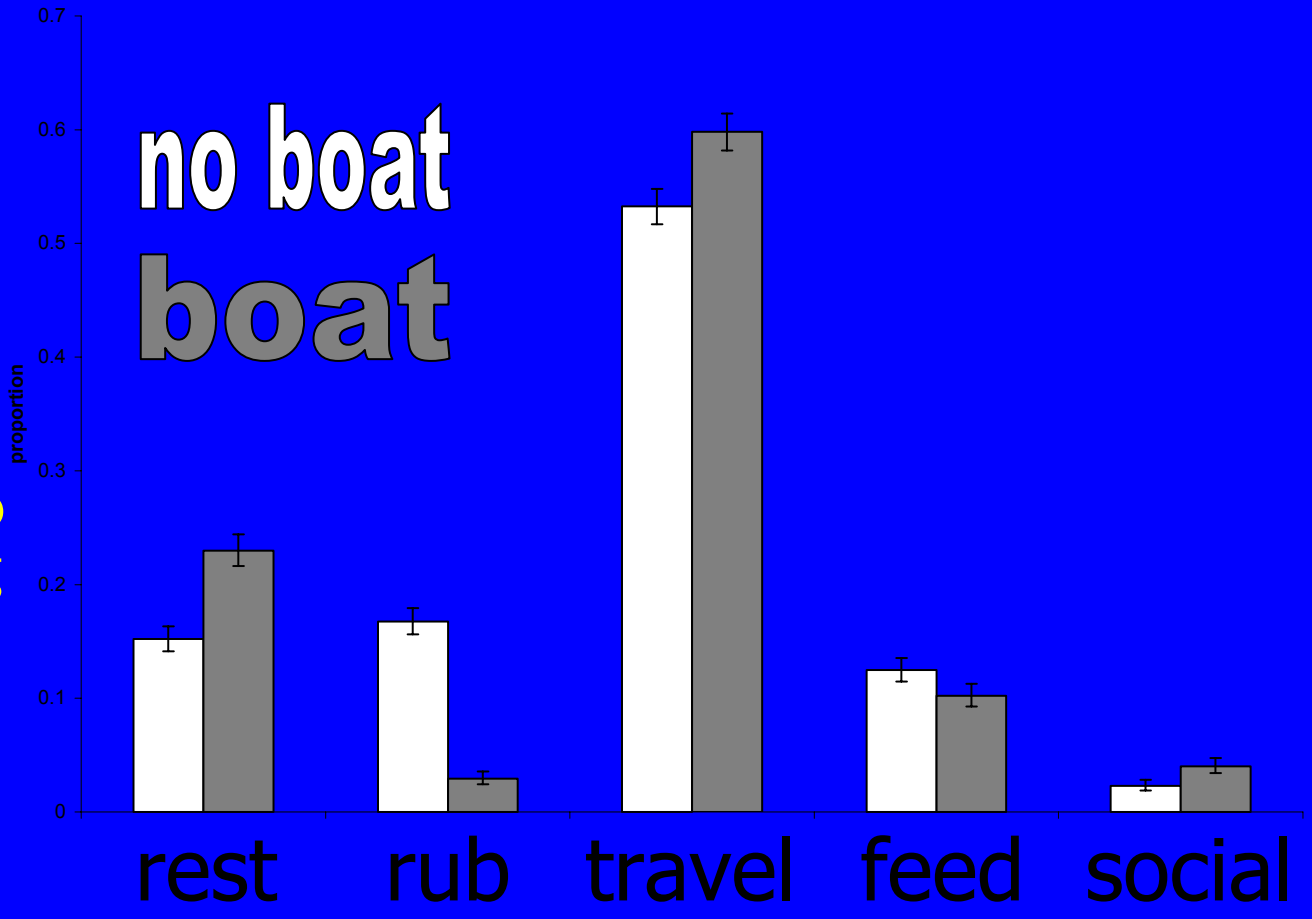
Sampling all whales, all activities

- 15min scans – 8yr
- no focal bias
- Markov-chain modeling
- whales likelier to stop feeding after 15min with boats present than absent
- not all activities equally vulnerable to disturbance

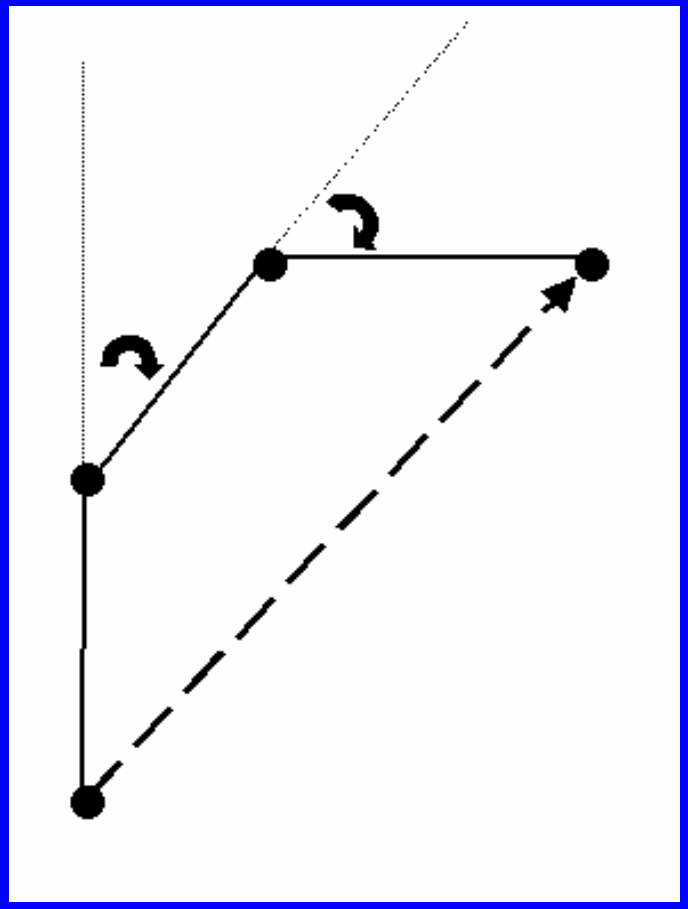


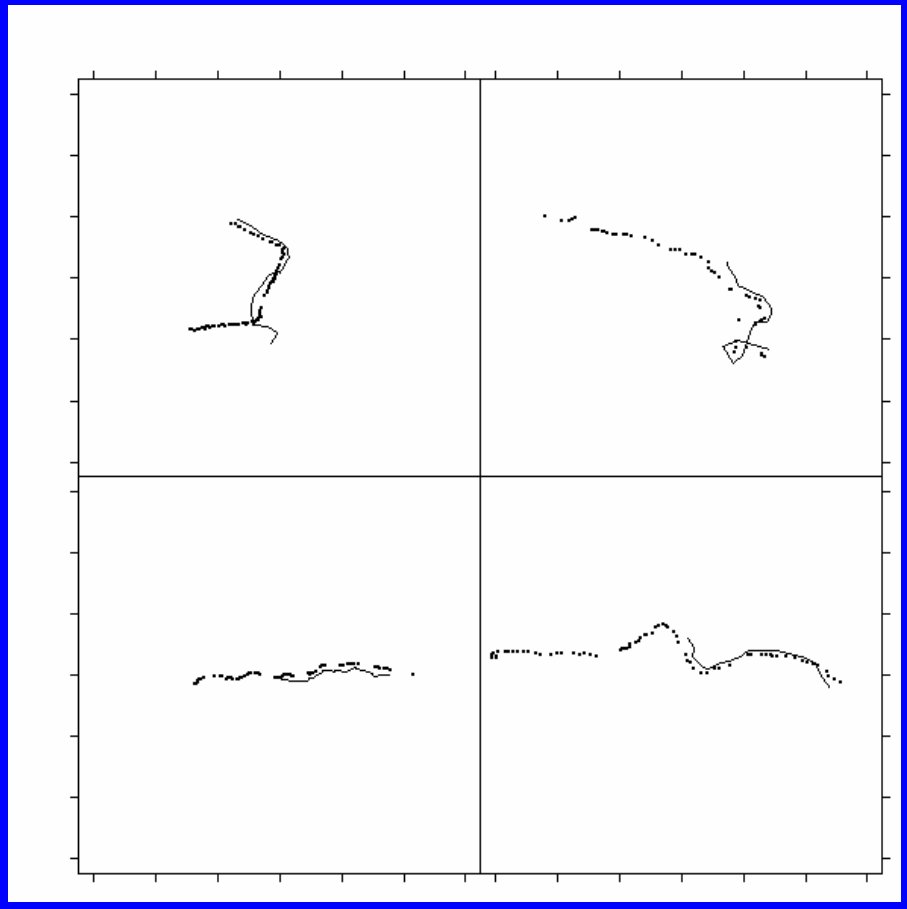
Effect of boats on activity budgets

- **stationary distribution = unbiased activity budget**
- **activity budgets differ**
- **boats cut into whales' feeding budget (and beach rubbing)**



Surfacing Patterns

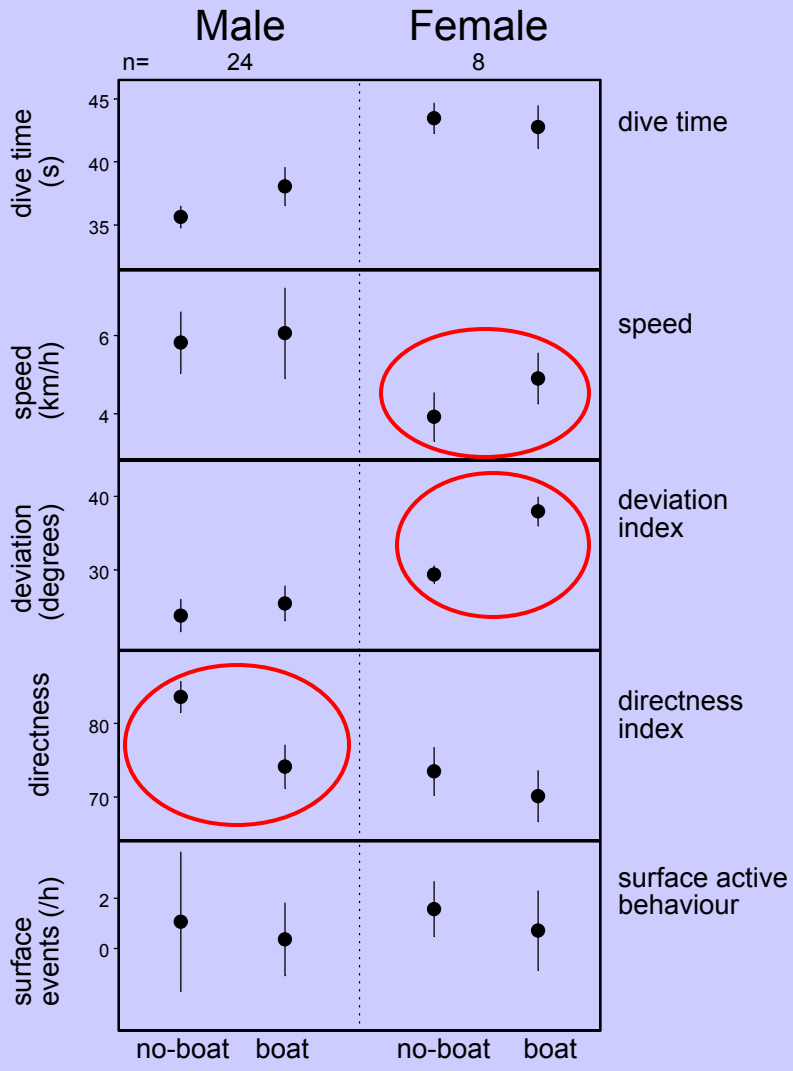




··· whale

— boat

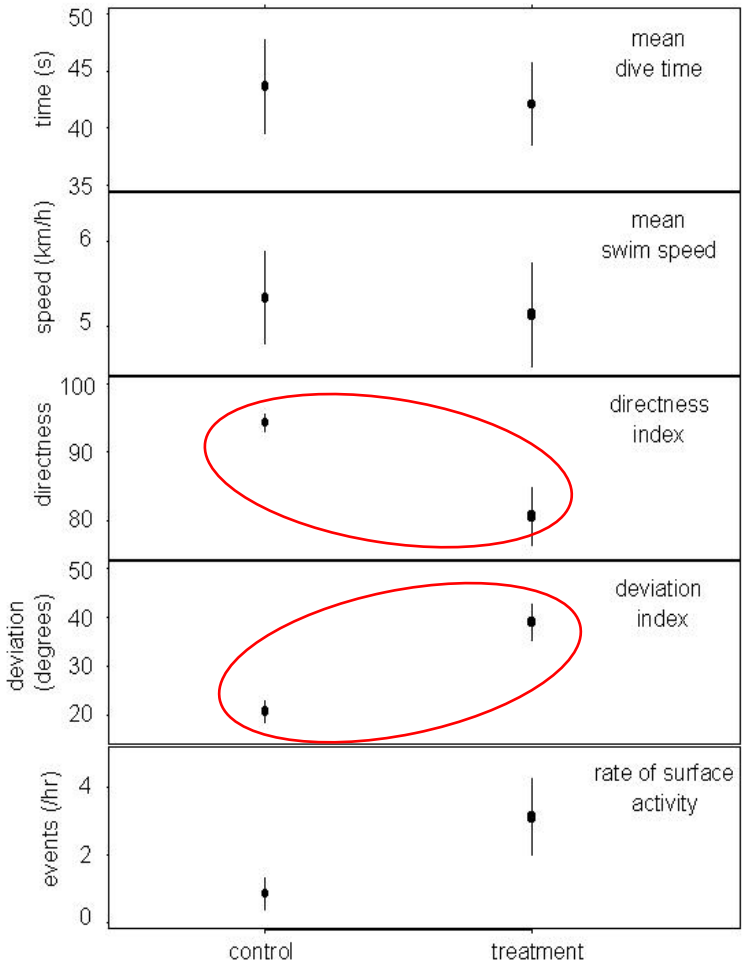
So what?



- not all behaviors changed
- results consistent with *horizontal avoidance*
- swim **13%** farther to get where they need to go
- that may cost energy

Williams *et al*. 2002a

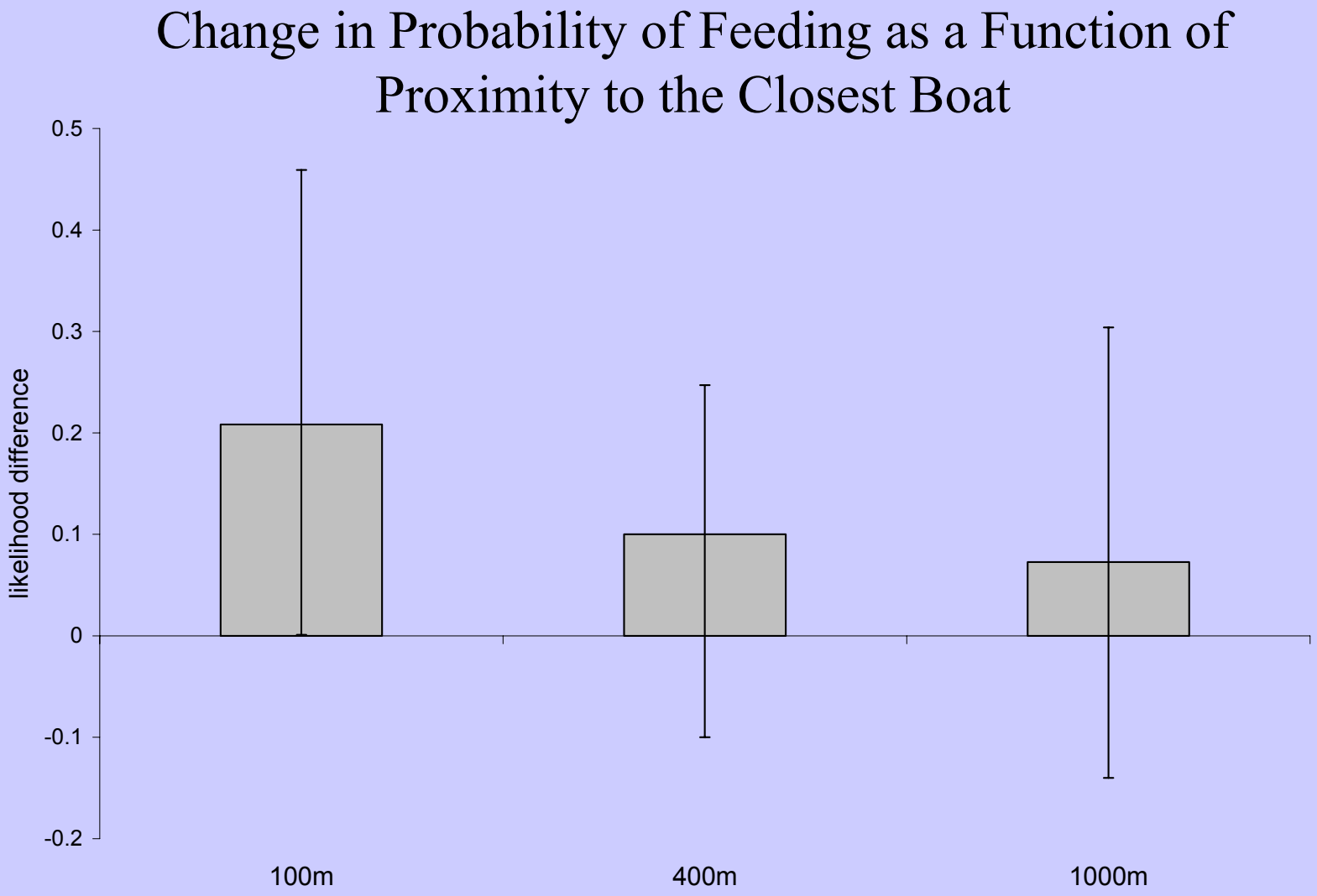
Speed Matters



- whales used the same, but more obvious, response as to a paralleling zodiac
- response to leapfrogging at ~150m was detectable with observations on only 10 animals

(Williams *et al*. 2002b)

Distance Matters



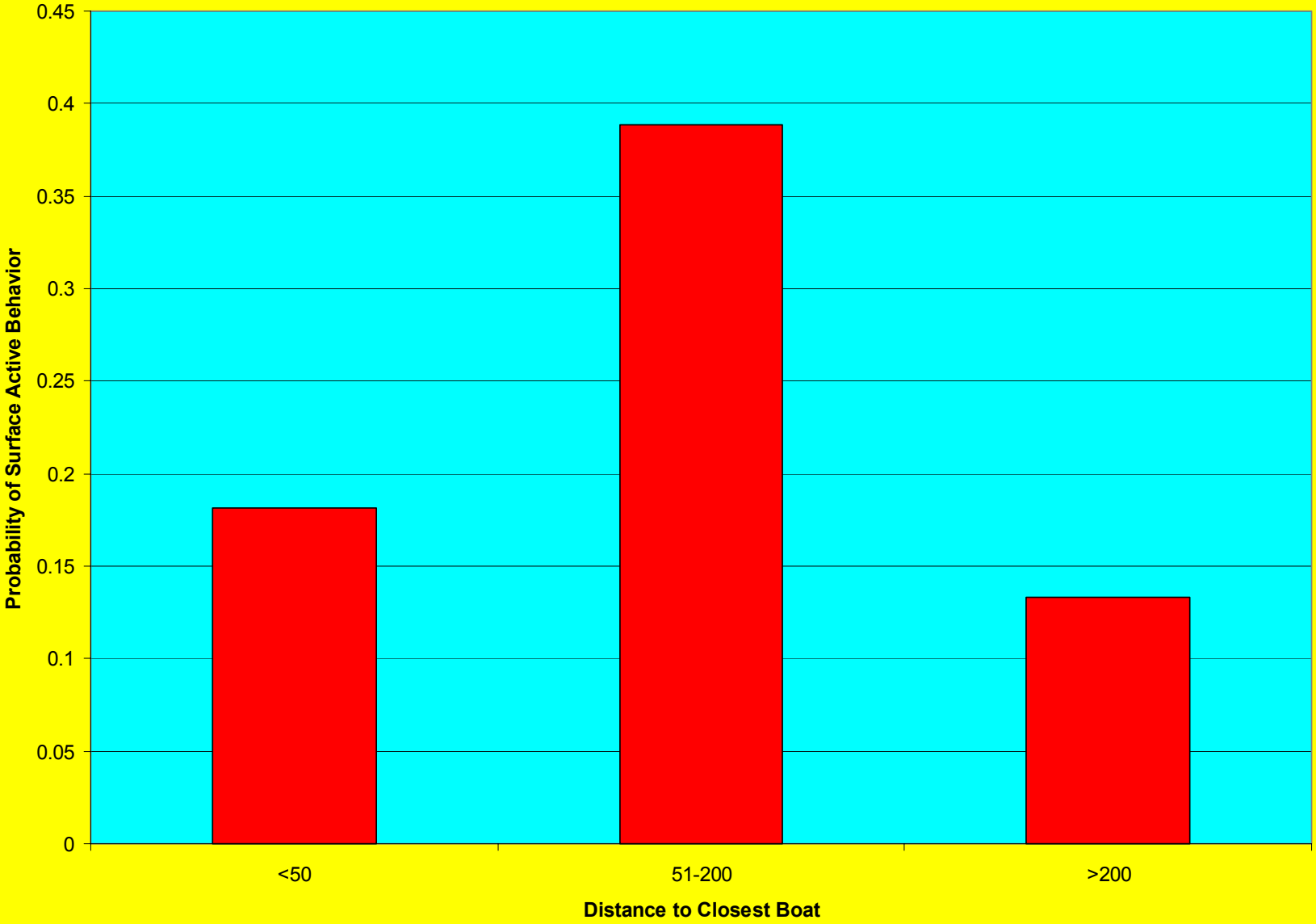
Distance Matters
(Southern Residents 2003)

DISTANCE	<400	>400
Dive Time	56.2	44.2
Speed	6174	6462
Deviation	29.3	23.4
Directness	74.2	77.8
Surface Active	0.658	2.857

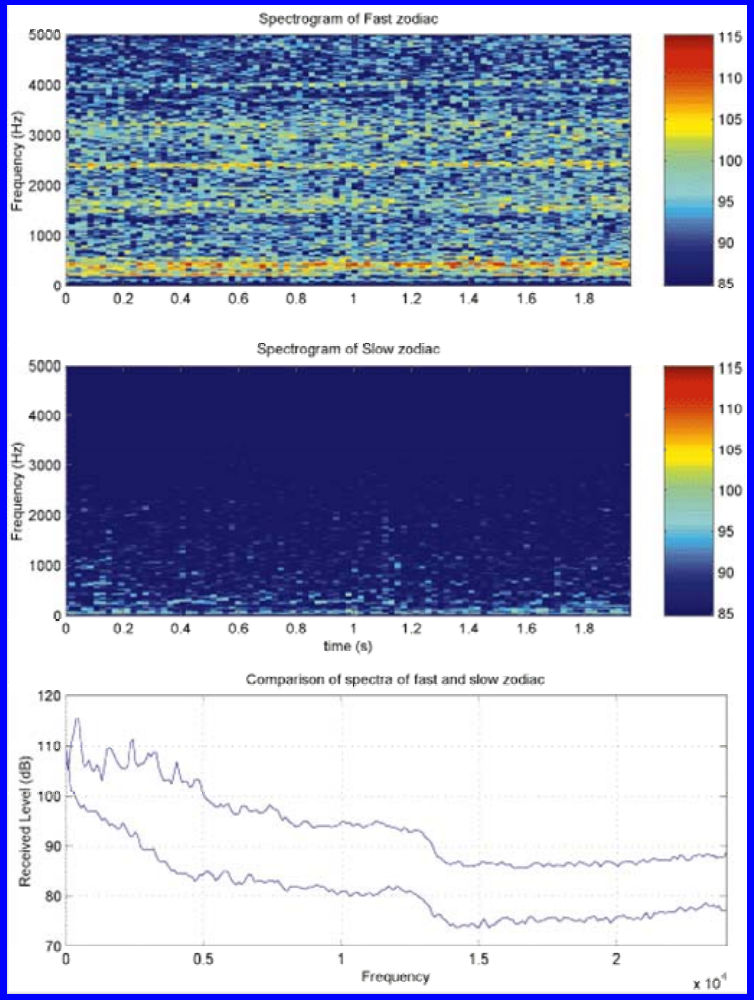
significantly different

non-significant but in same direction as Northern Residents

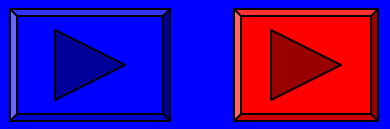
Distance Matters



Why is leapfrogging so disturbing?



- when an outboard speeds up, noise gets louder, and higher in frequency
- noise placed directly in front of whale, which causes most masking

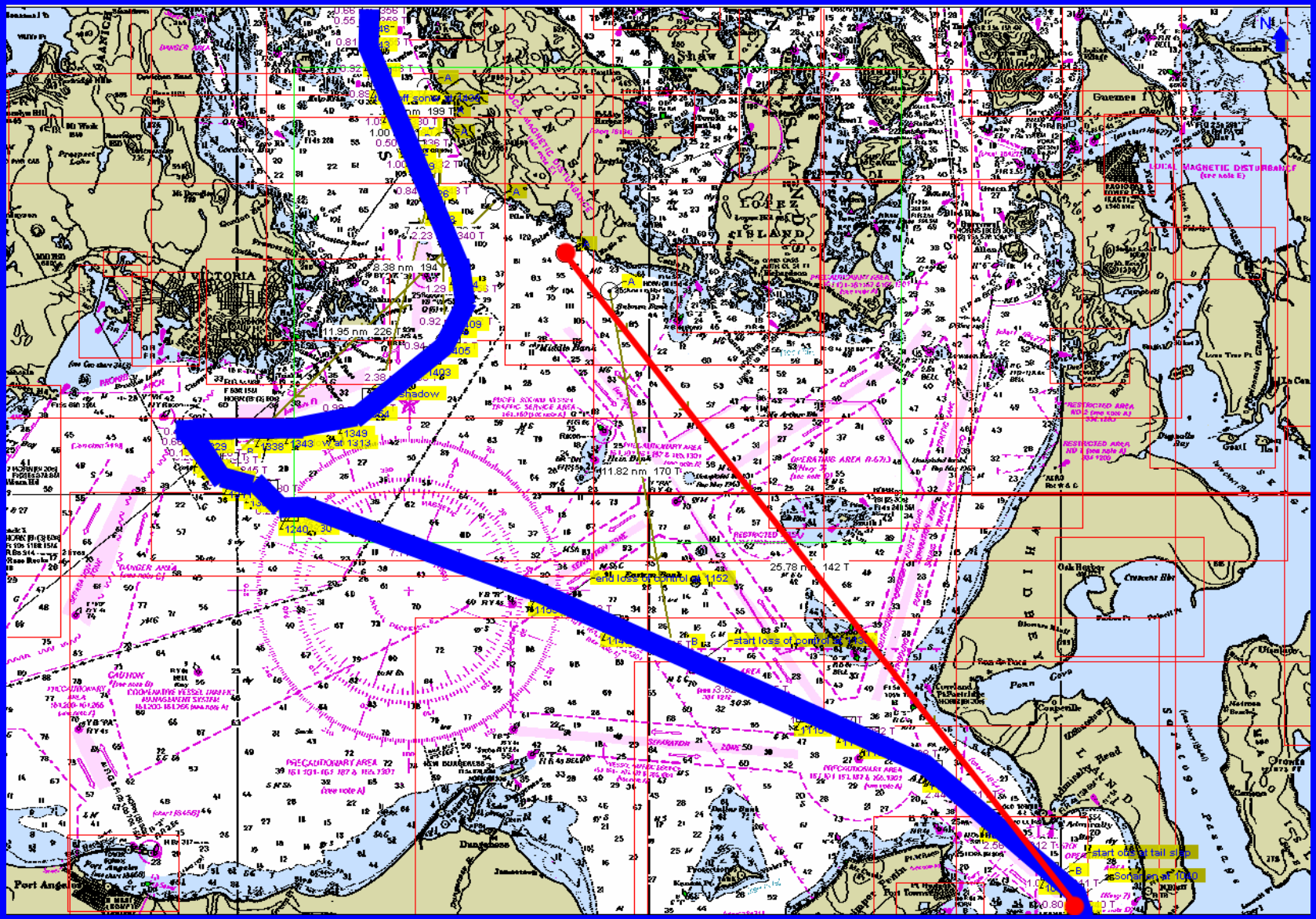


- received noise of fast boat at 500m equaled slow boat at 100m

Deep Water Path Established
Tail Slap

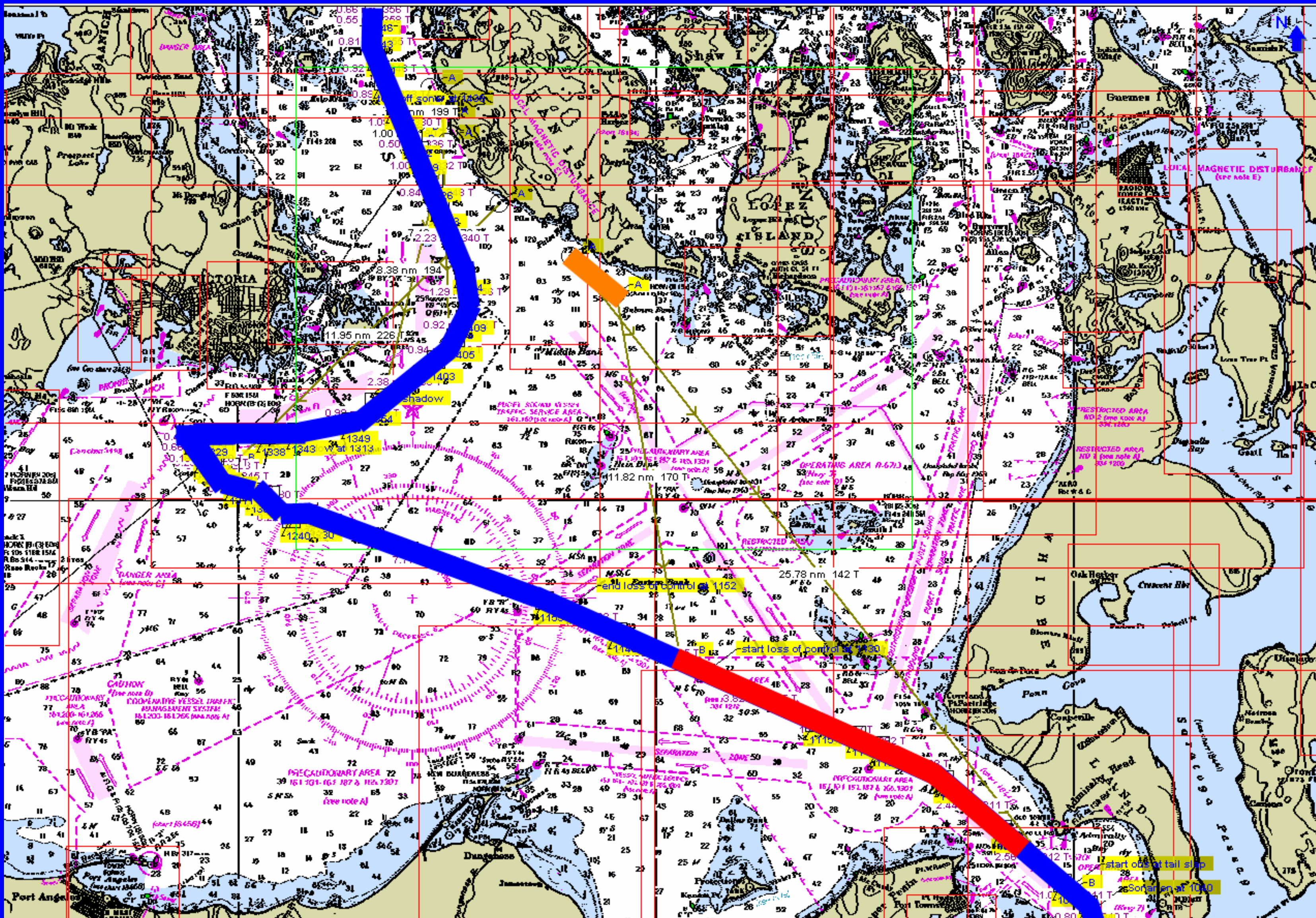
Distance = 47 km, 26 nm

Time: 1047



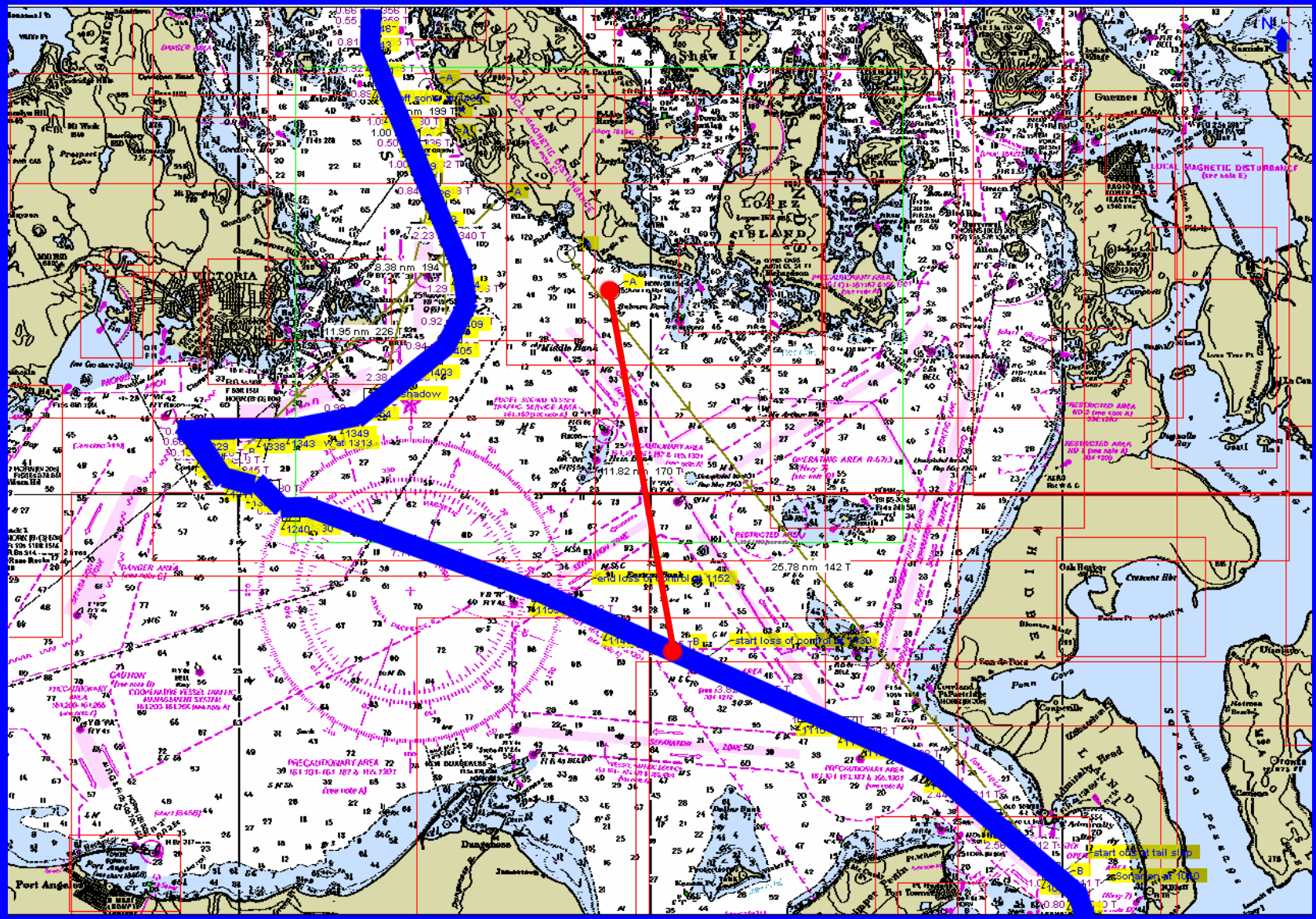
No Deep Water Path
J Pod behaving normally

Distance = 47-22 km, 26-12 nm
Time: 1047-1134



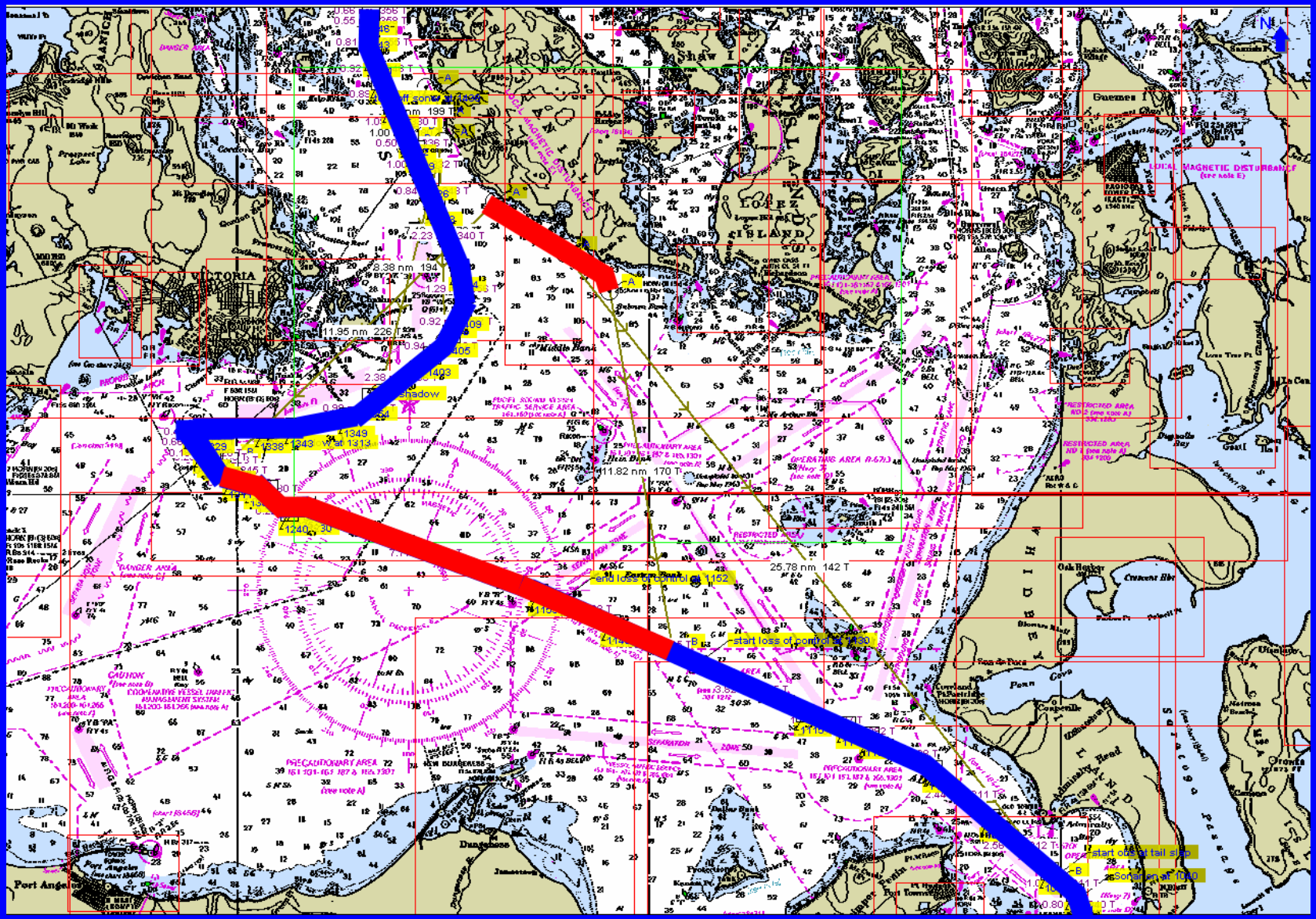
Deep water path established
J Pod turns to move away

Distance = 22 km, 12 nm
Time: 1134



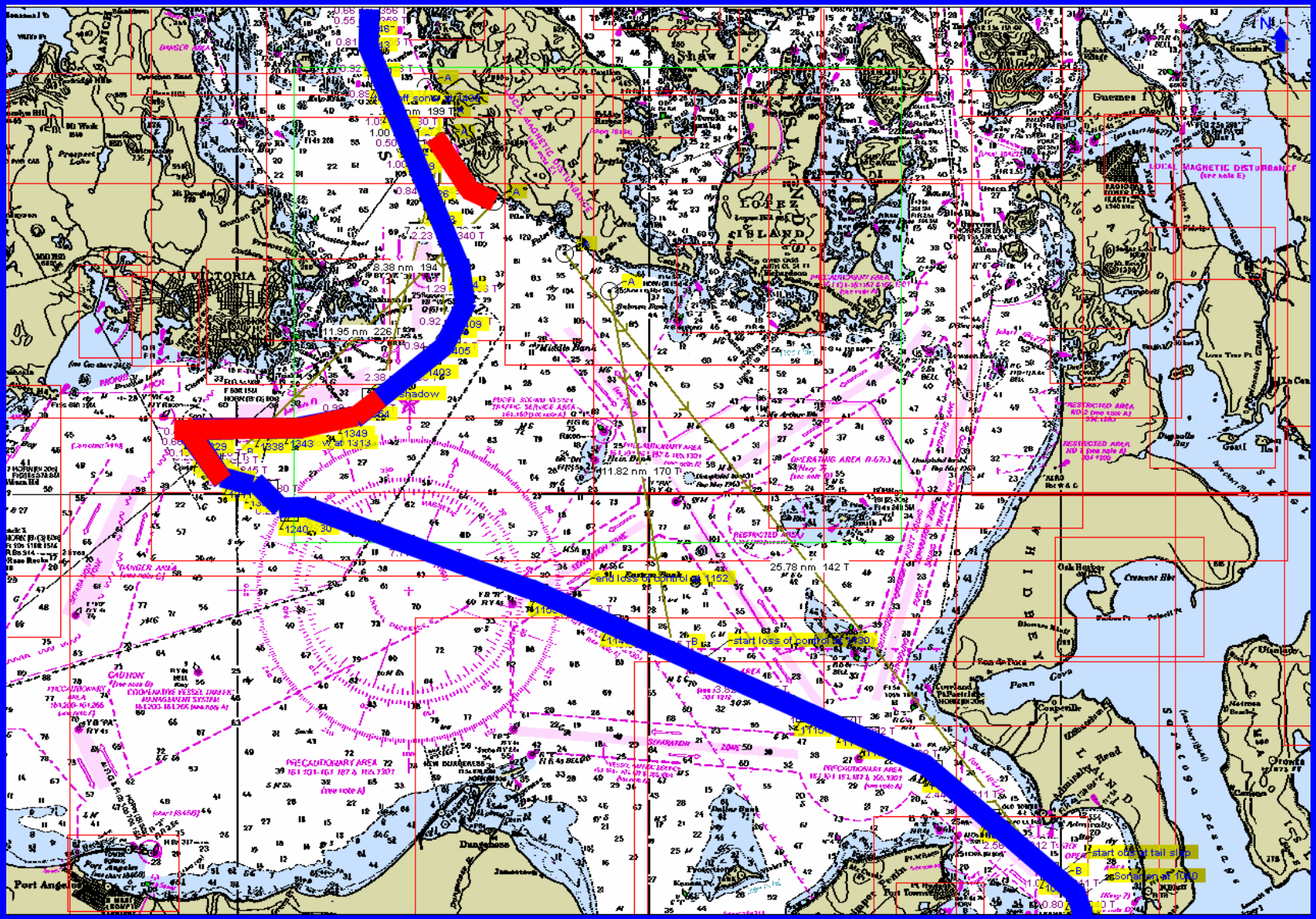
Deep Water Path **Distance = 18-22 km, 10-12 nm**

J Pod behaving abnormally **Time: 1134-1314**



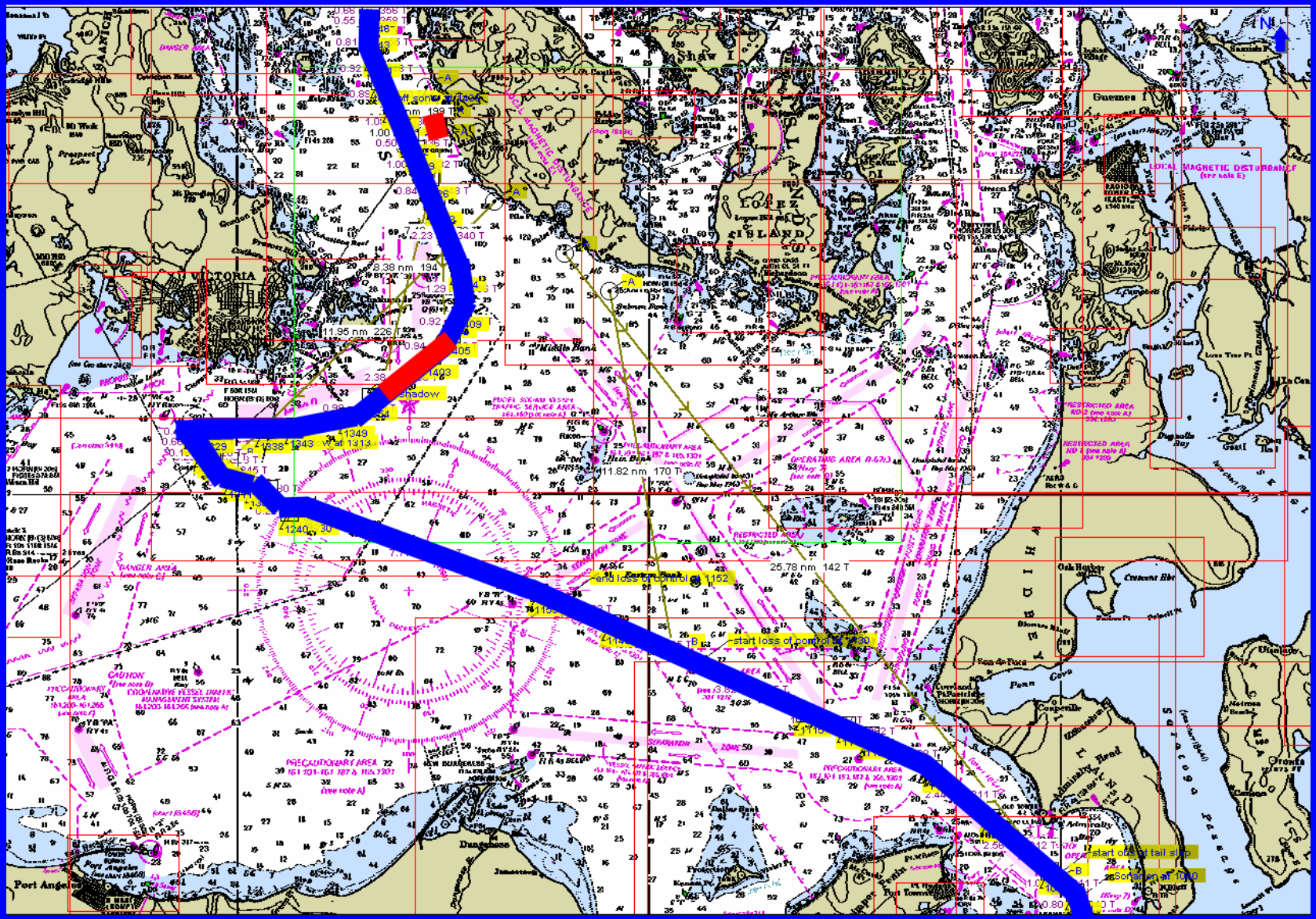
No Deep Water Path
J Pod normal (slow, spread)

Distance = 15-22 km, 8-12 nm
Time: 1314-1355



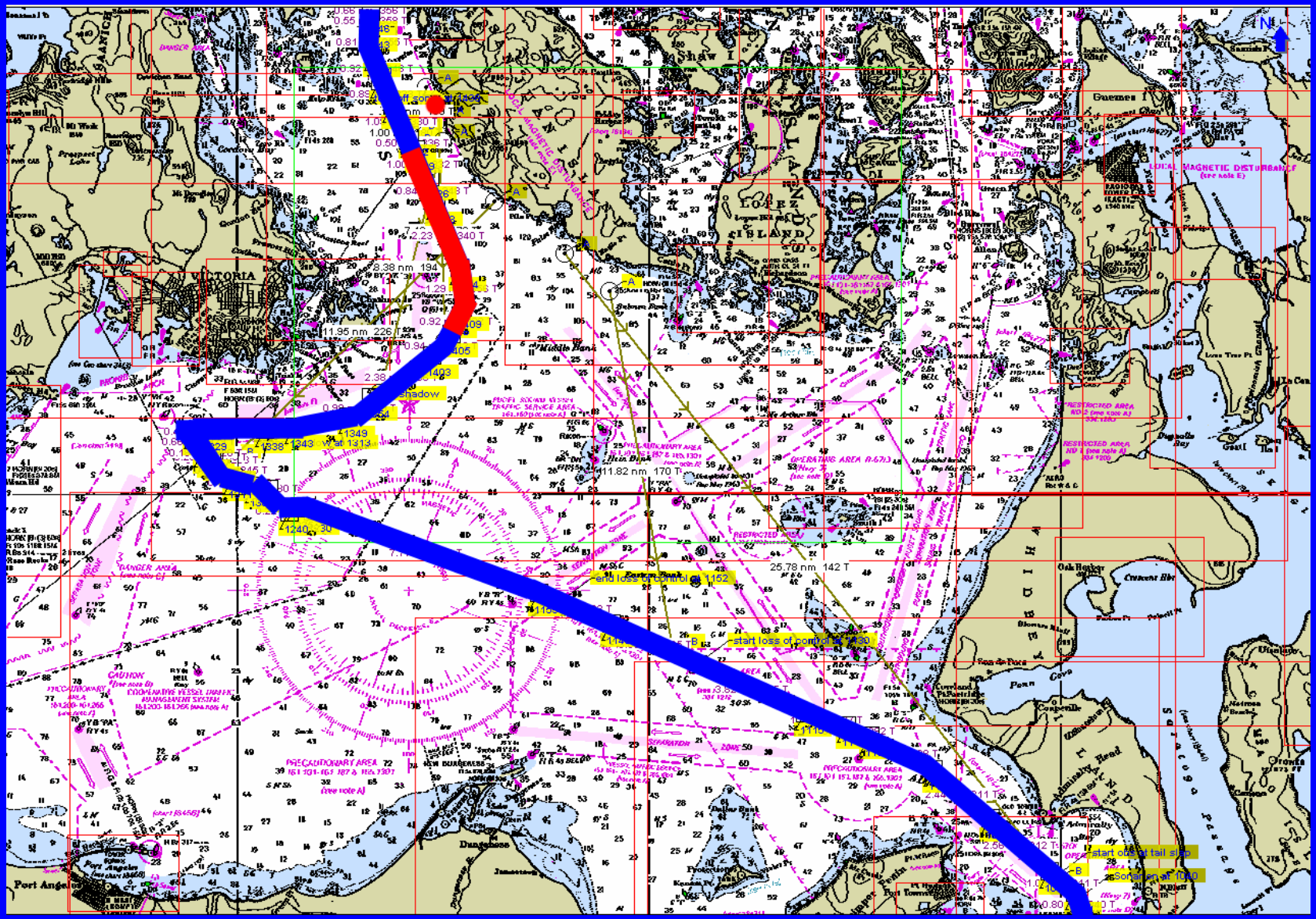
Deep Water Path
J Pod Abnormal

Distance = 13-15 km, 7-8 nm
Time: 1355-1407



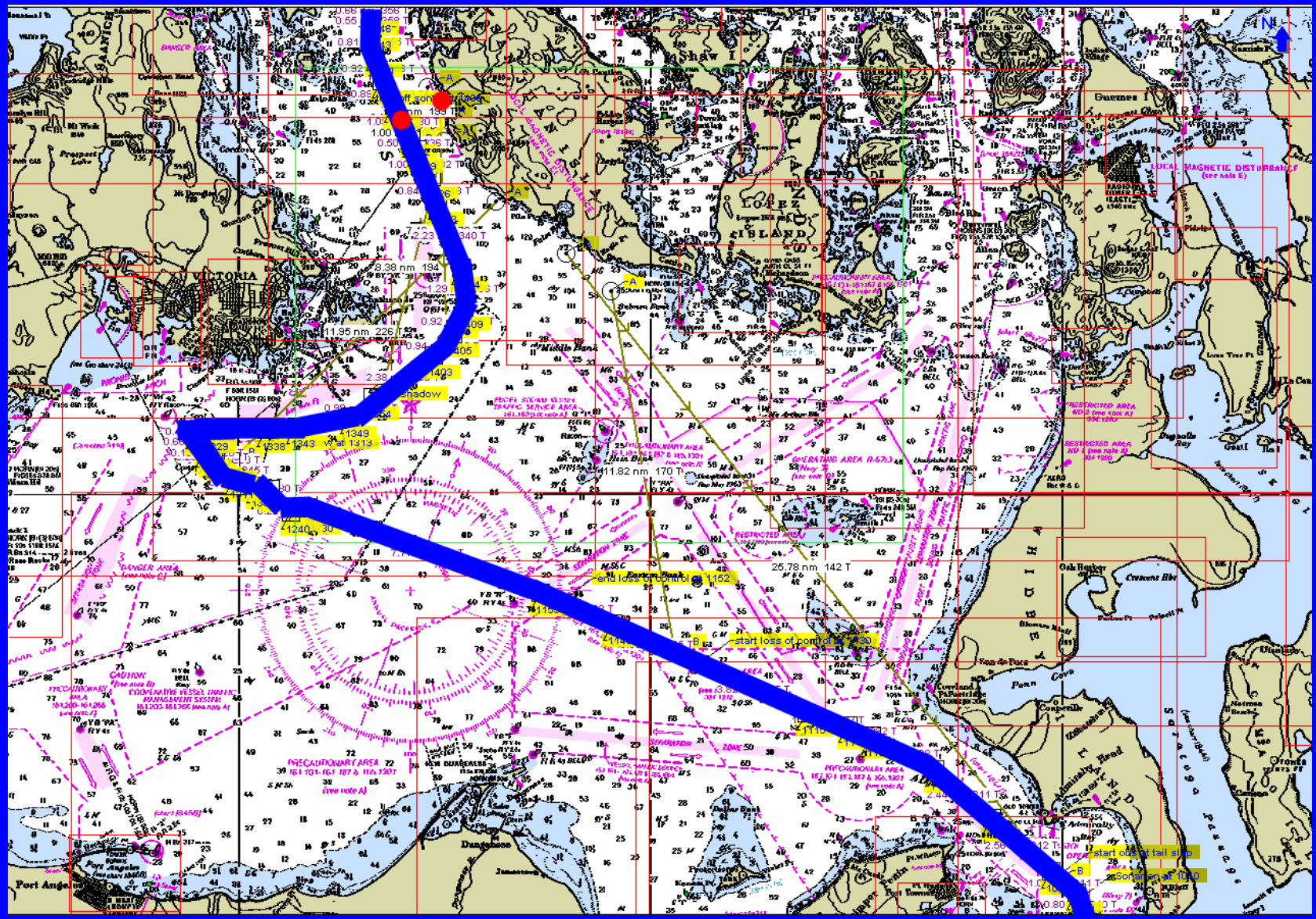
No Deep Water Path
J Pod staying in shadow zone

Distance = 4-13 km, 2-7 nm
Time: 1407-1432



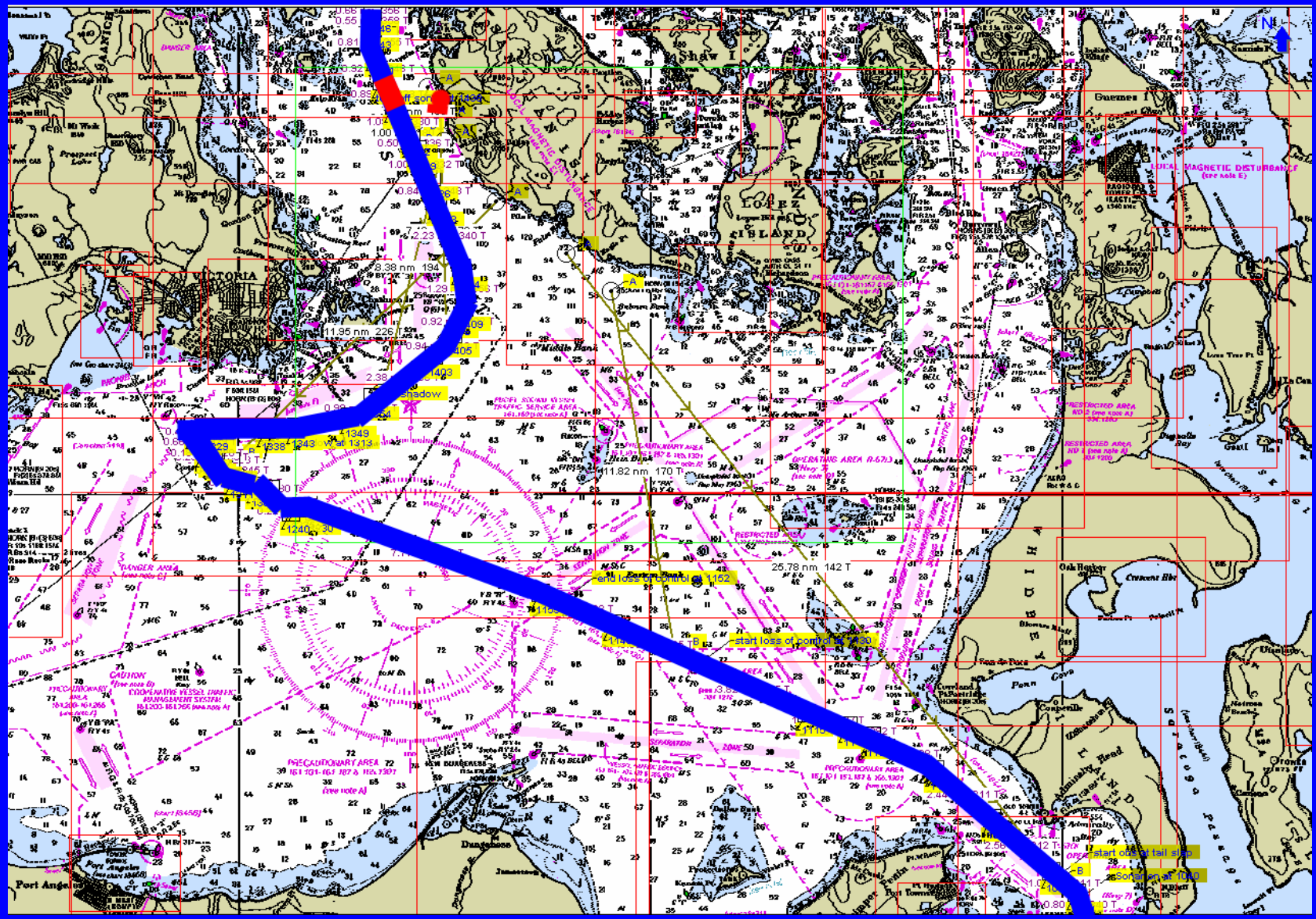
Closest approach **Distance = 3 km, 1.7 nm**

J Pod splitting **Time: 1432**



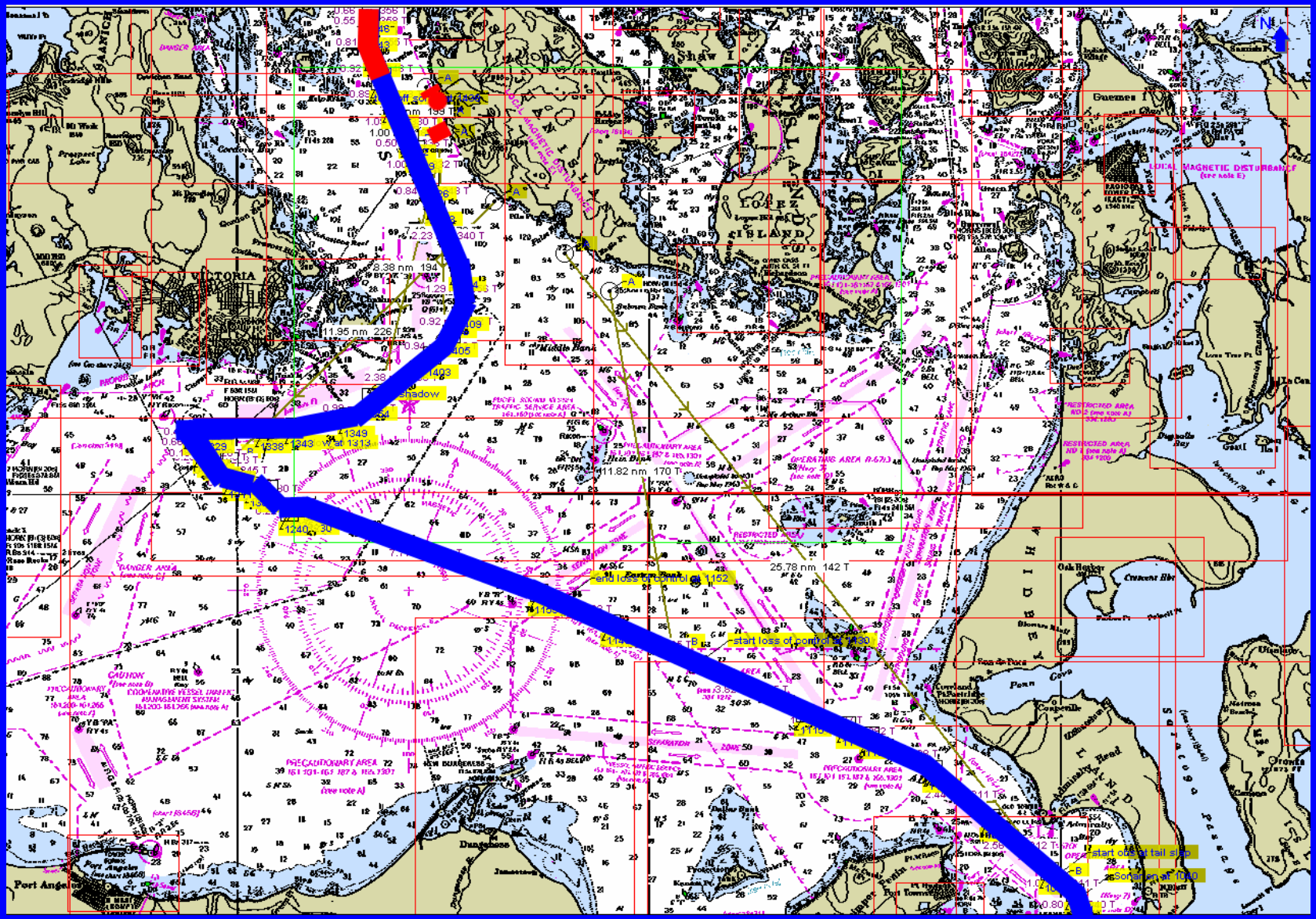
Shoup moving away **Distance = 3-4 km, 2 nm**

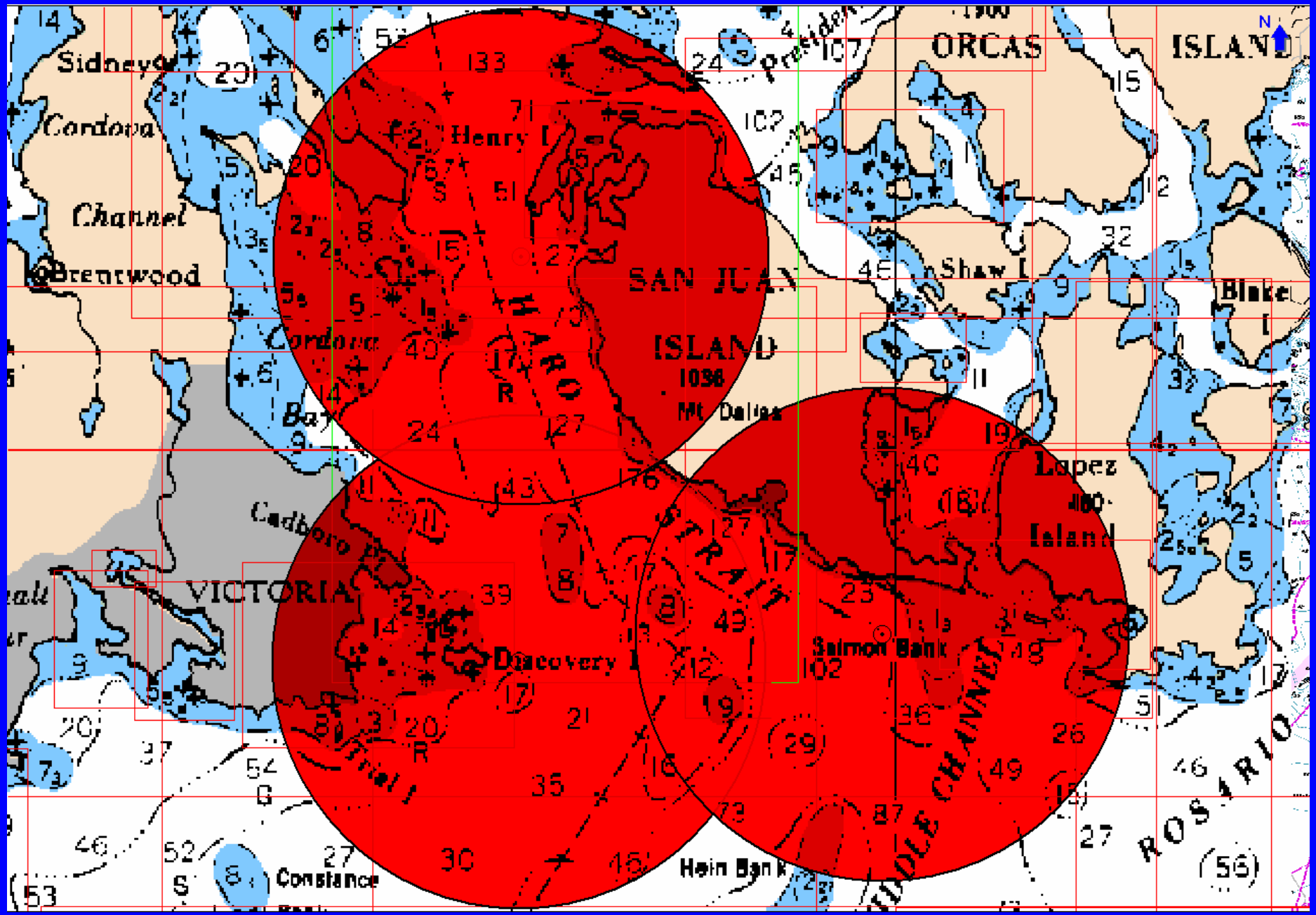
J Pod splitting, part moving away **Time: 1432-1438**

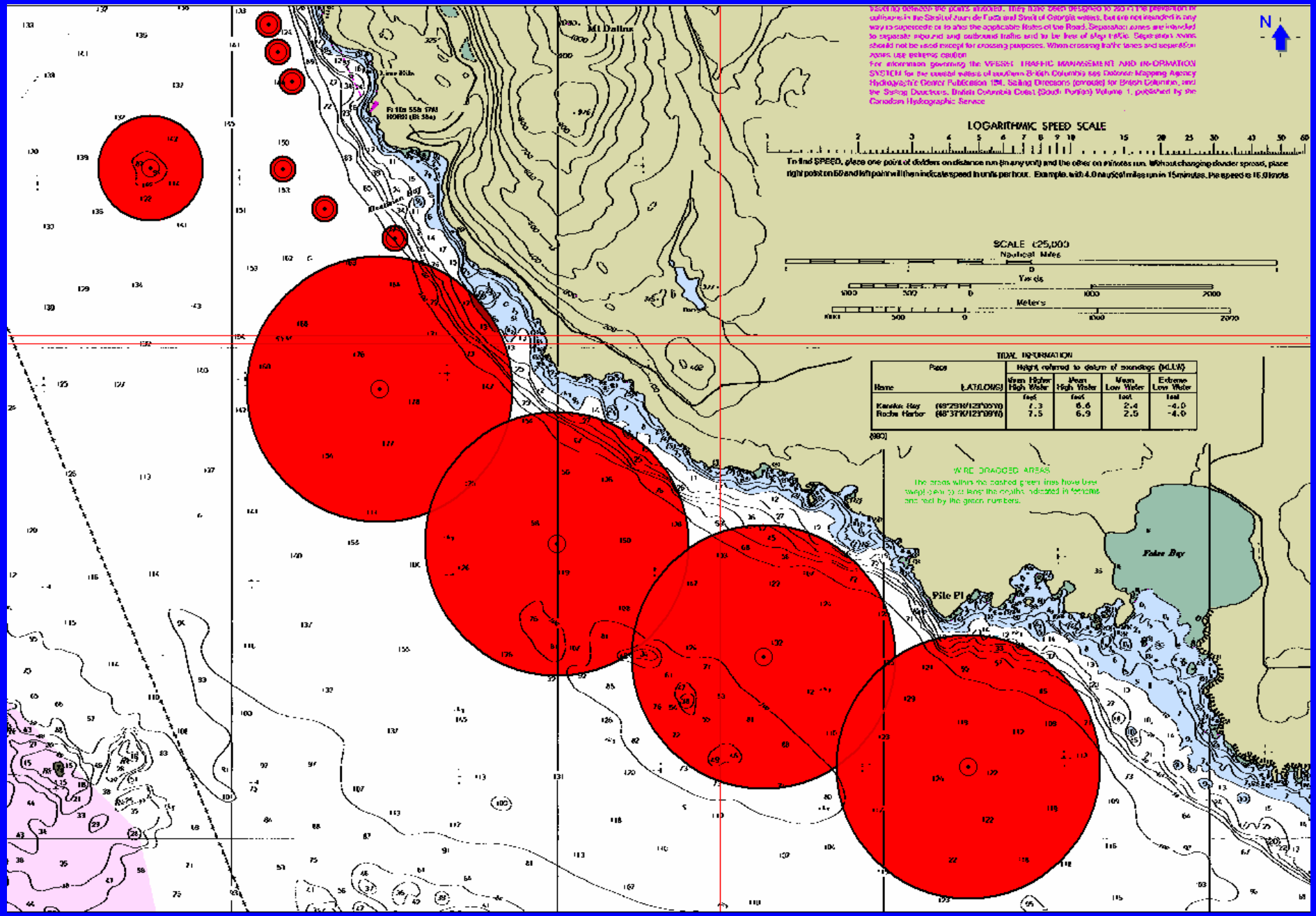


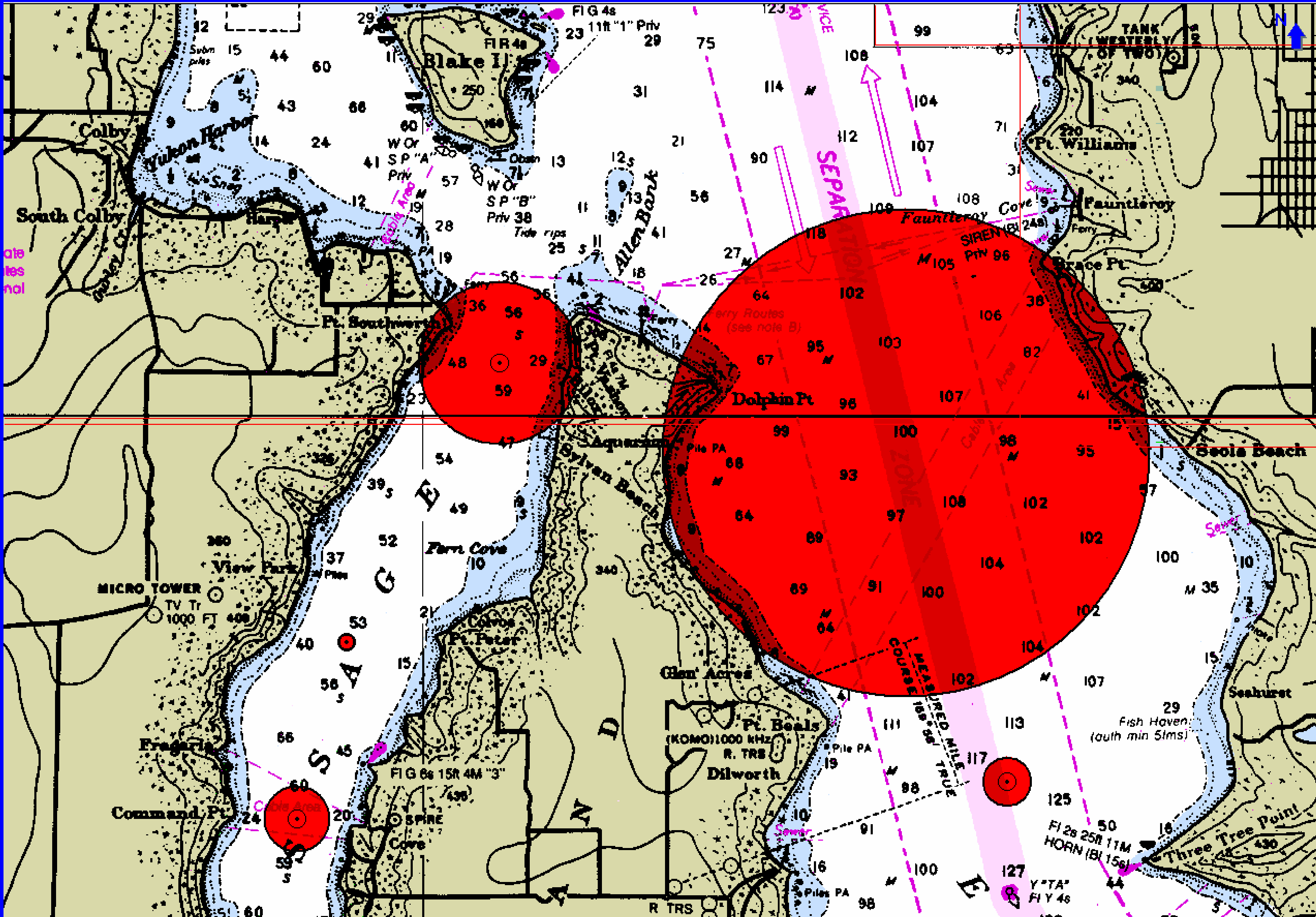
Sonar off **Distance = 4+ km, 2+ nm**

J Pod split, moving offshore, spreading out Time: 1438-1452

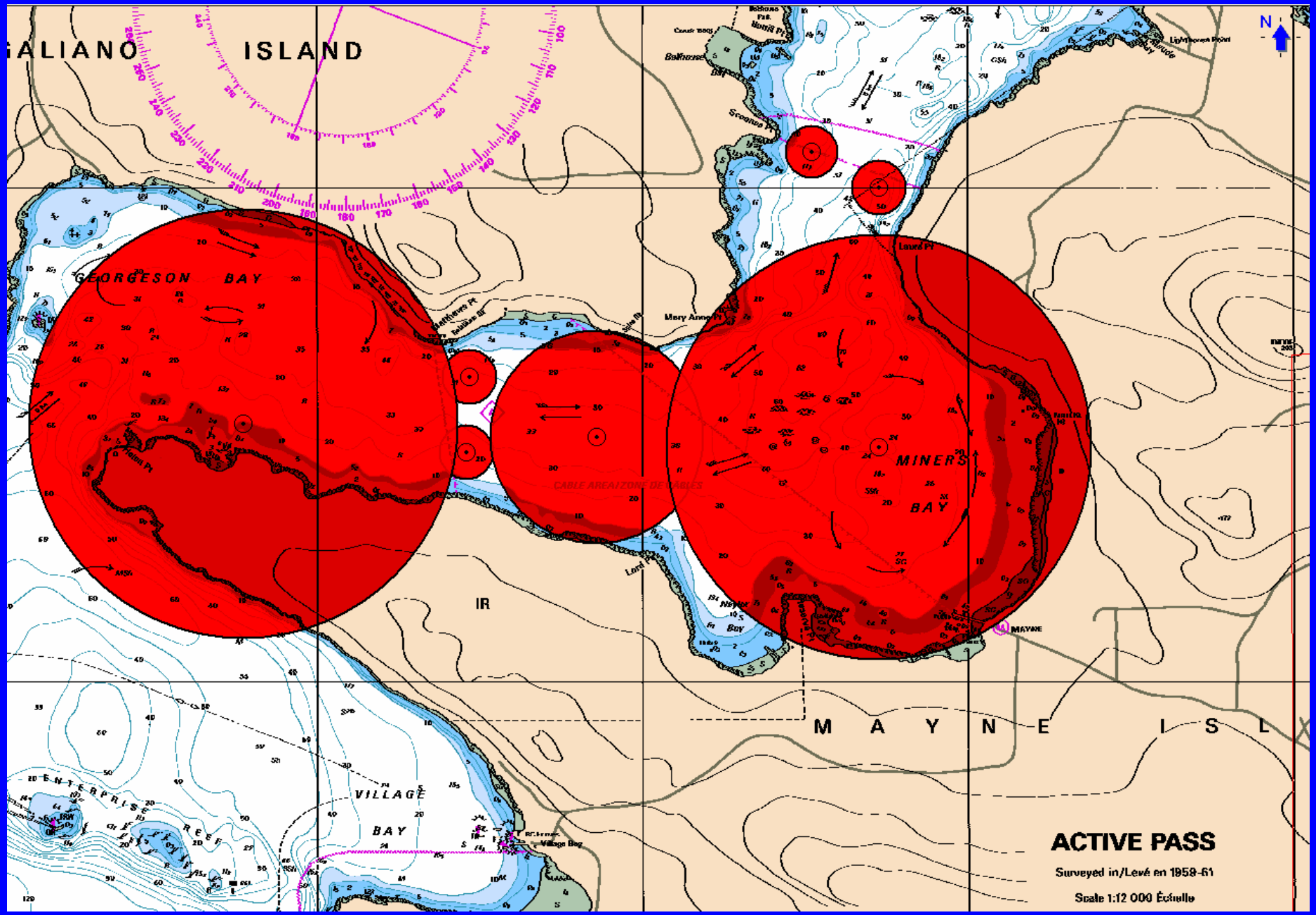


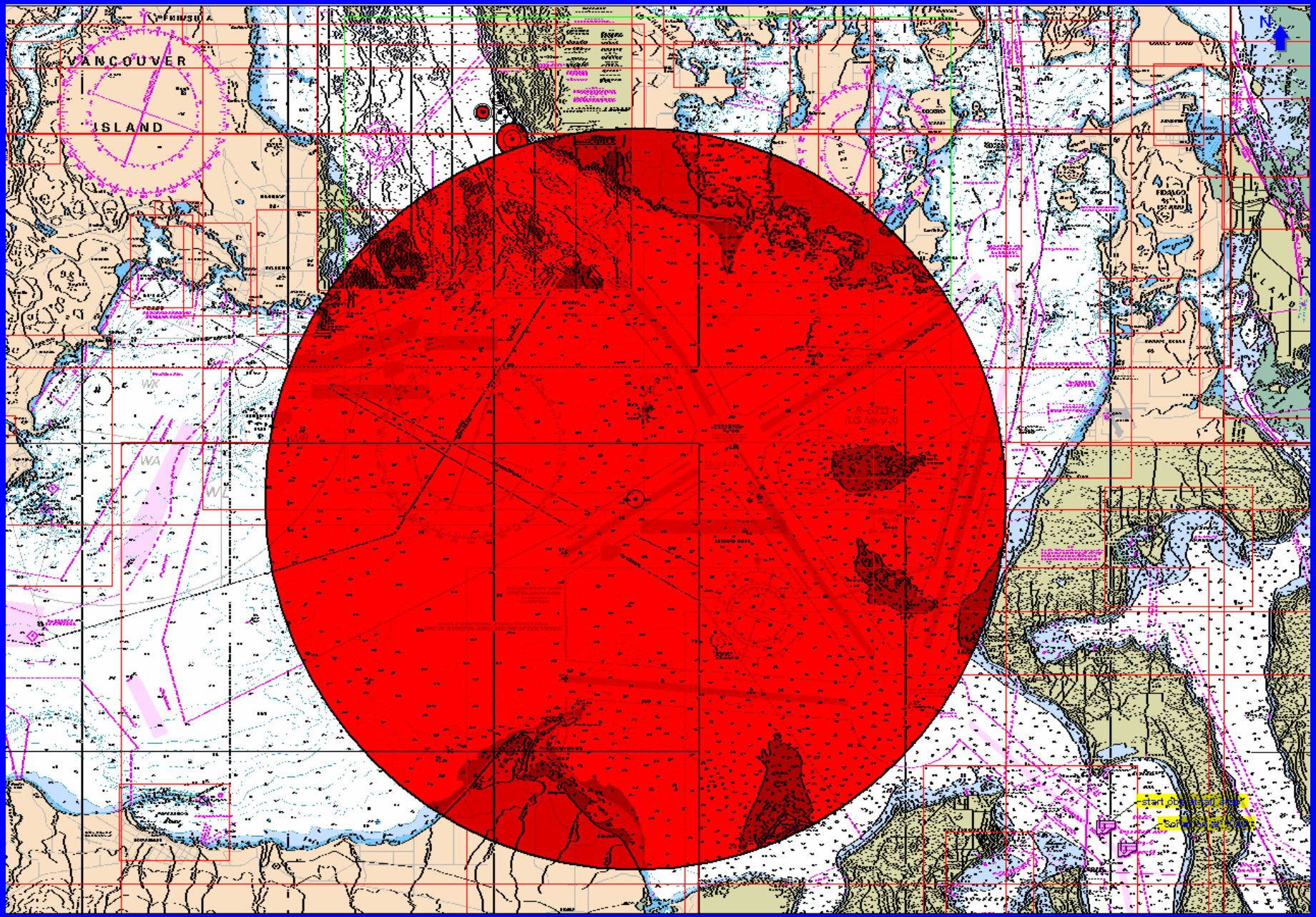

Sidney
Cordova
Channel
Brentwood
Cordova
Bay
Henry I
SAN JUAN
ISLAND
1036
Mt Dallas
ORCAS
ISLAND
Shaw I
Blake
Lopez
Island
Cadboro Pt
VICTORIA
Discovery I
Trial I
Constance
Hein Bank
Salmon Bank
HAROLD CHANNEL
ROSARIO
N

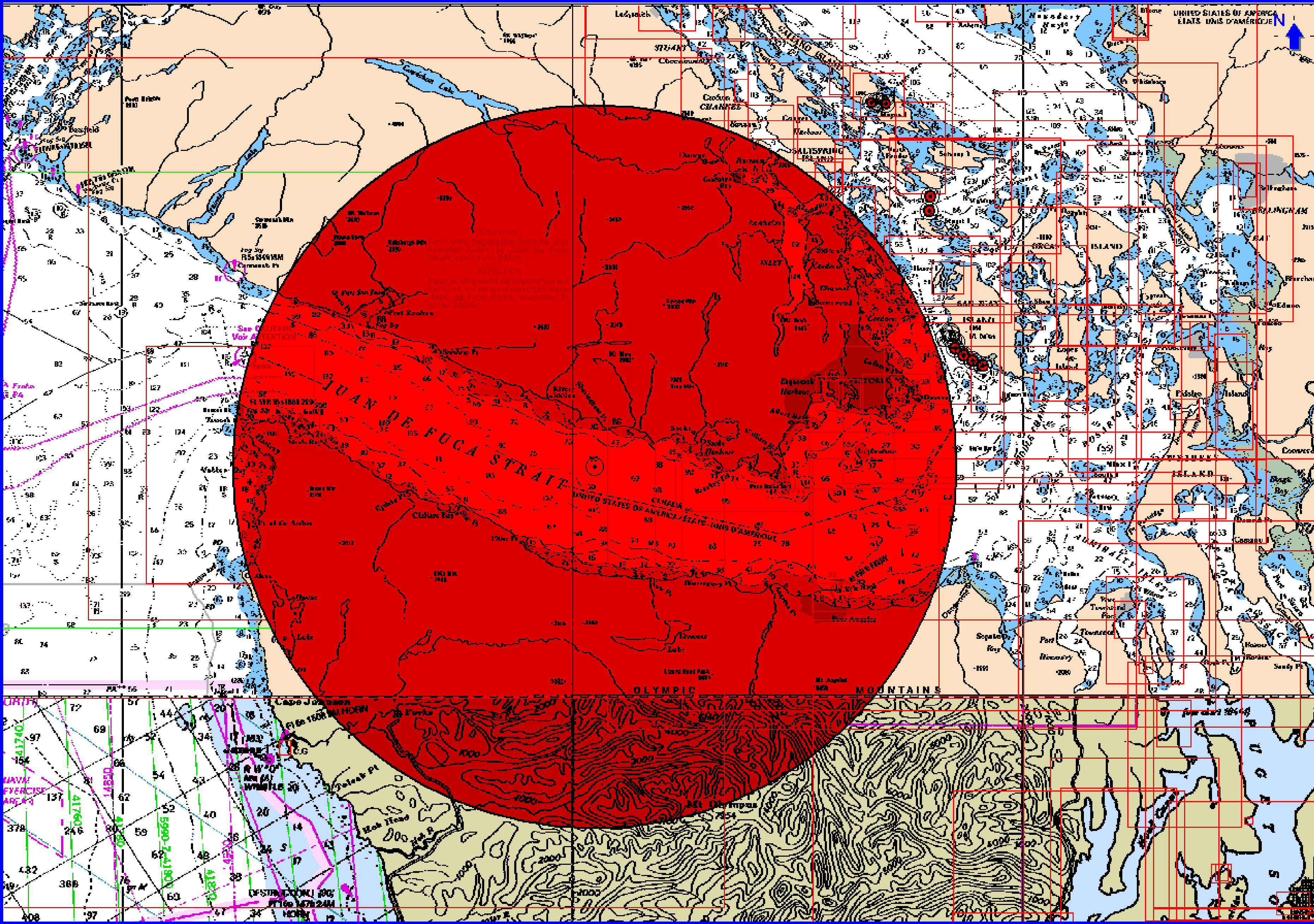

Mt Dallas
Pile Pt
False Bay
N
LOGARITHMIC SPEED SCALE
SCALE 1:25,000
Nautical Miles
Yards
Meters
TIDAL INFORMATION
WRD DREDGED AREAS

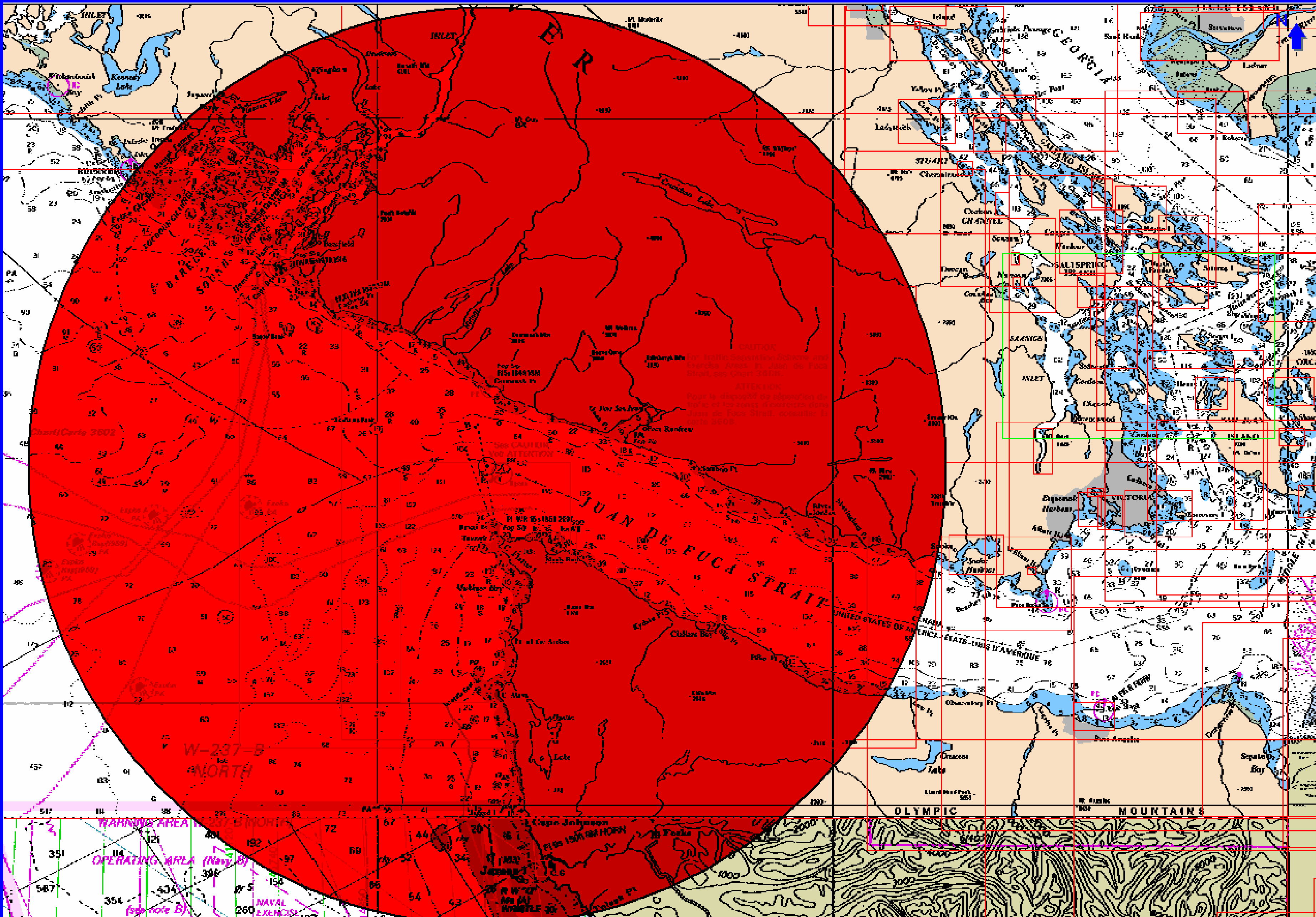


Blake I.
Colby
South Colby
Yukon Harbor
Harper
Pt. Southworth
Allen Bank
Fauntleroy
Fauntleroy Cove
Pt. Williams
TANK WESTERLY OF TWO
Brace Pt.
SIREN Priv
Dolphin Pt
Aquarium
Sylvan Beach
Seola Beach
Fern Cove
View Park
MICRO TOWER
Colvos
Pt. Peter
Glen Acres
Pt. Beals
(KOMO)1000 kHz
Dilworth
Fragaria
Command Pt.
SPIRE
Cove
Seahurst
Three Tree Point
Fish Haven (auth min 5fms)
MEASURED MILE COURSE
SEPARATION ZONE
Tide rips
Ferry Routes (see note B)
Fl G 6s 15ft 4M "3"
Fl 2s 25ft 11M HORN (BI 15s)
Y "TA" Fl Y 4s


GALIANO ISLAND
GEORGESON BAY
MINERS BAY
CABLE AREA/ZONE DE CÂBLES
IR
MAYNE ISLAND
VILLAGE BAY
ENTERPRISE REEF
ACTIVE PASS
Surveyed in/Levé en 1958-61
Scale 1:12 000 Échelle
N

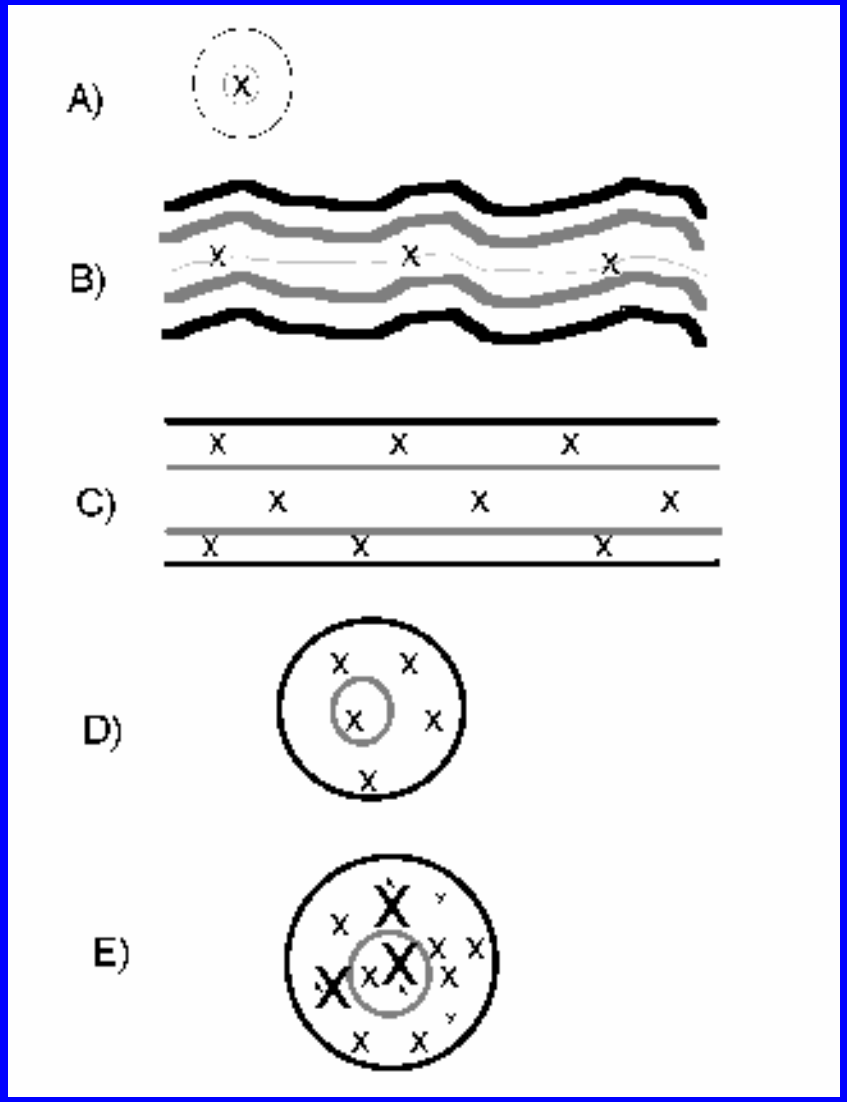

VANCOUVER
ISLAND
N

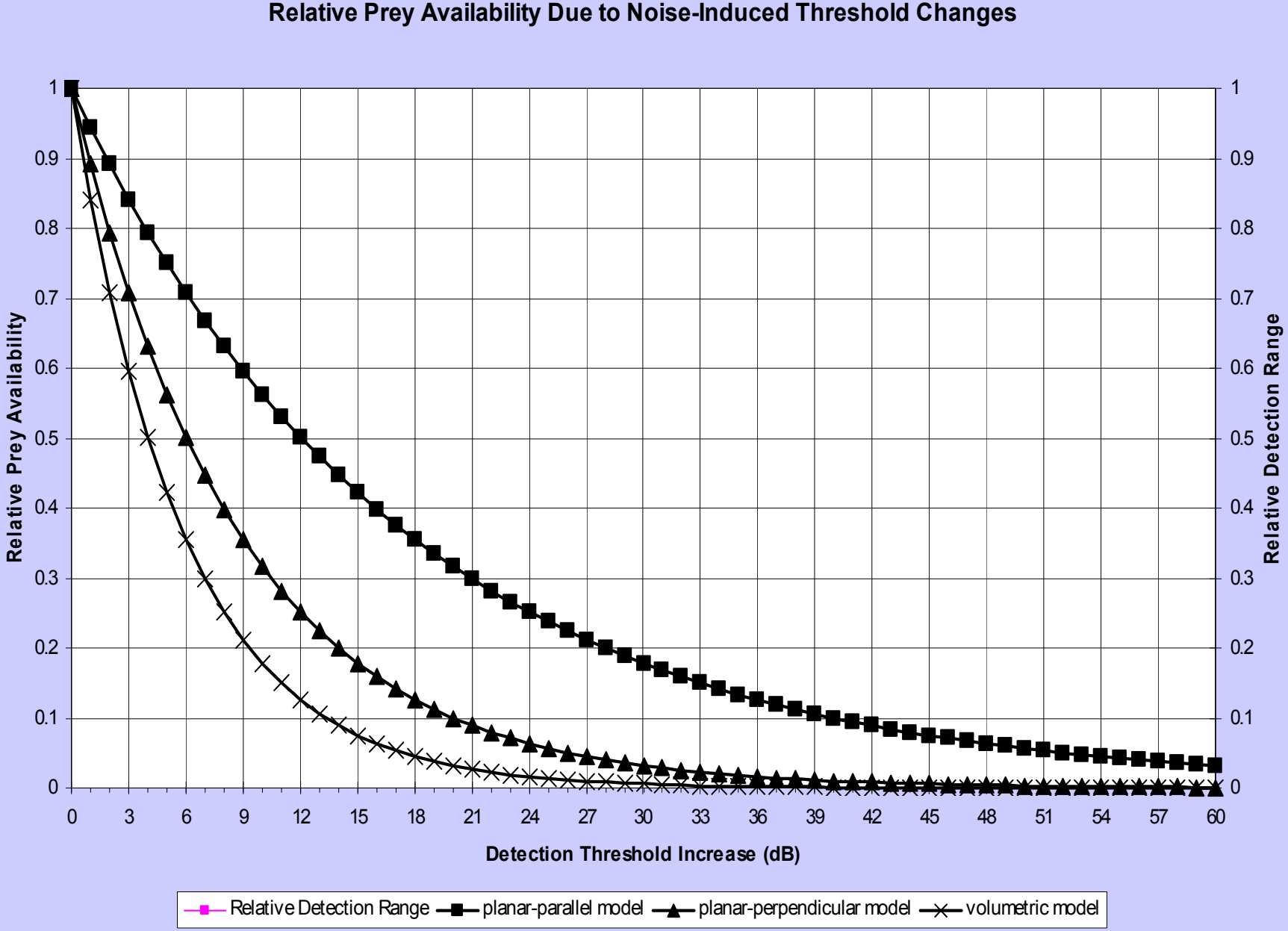

JUAN DE FUCA STRAIT
OLYMPIC MOUNTAINS
UNITED STATES OF AMERICA
N



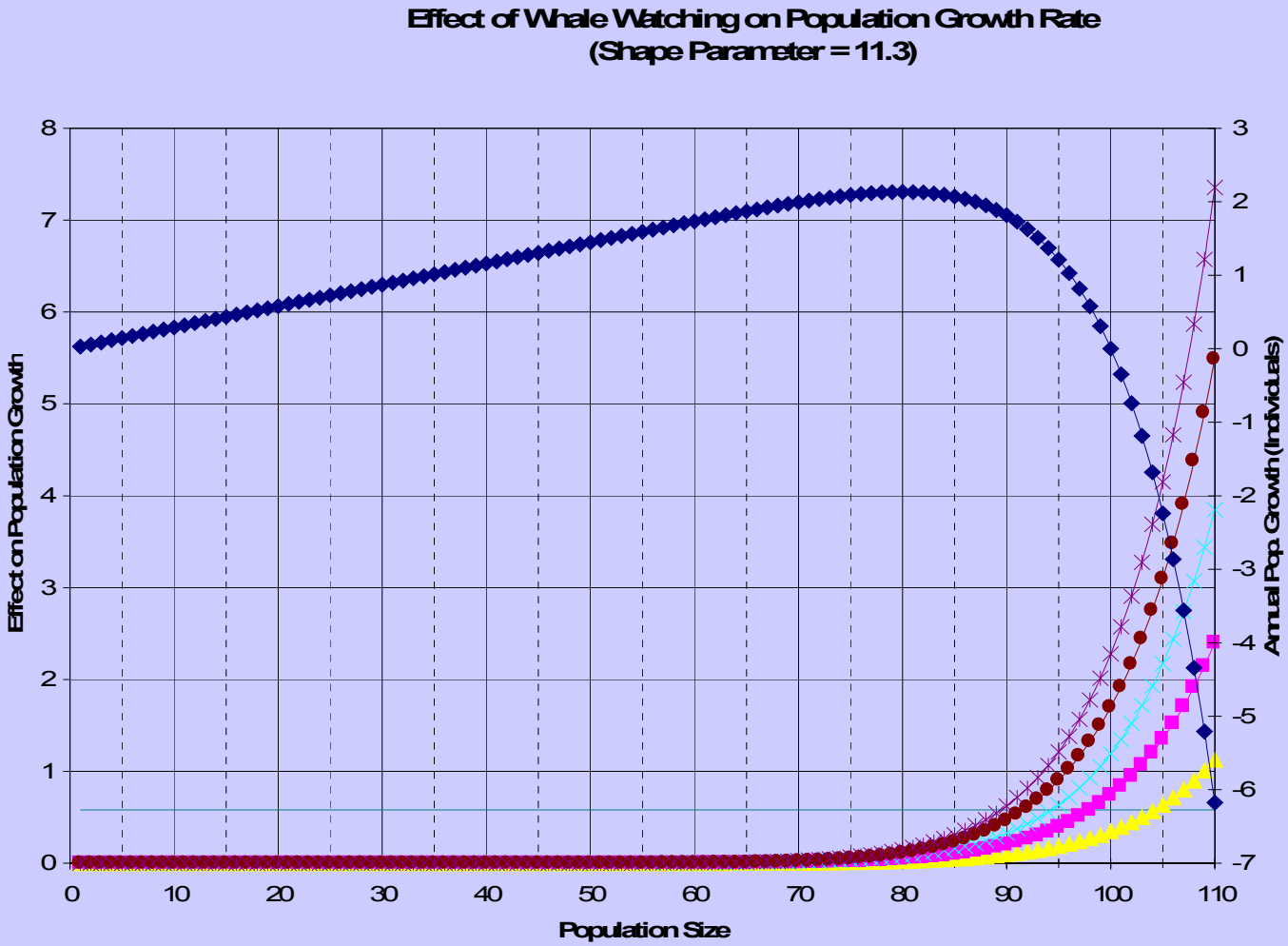
JUAN DE FUCA STRAIT
UNITED STATES OF AMERICA
ÉTATS-UNIS D'AMÉRIQUE
OLYMPIC MOUNTAINS
GEORGIA
SAANICH
VICTORIA
Port Angeles
W-237-B NORTH
WARNING AREA
OPERATING AREA (Navy 8)
See CAUTION

Foraging tactics




Relative Prey Availability Due to Noise-Induced Threshold Changes
Relative Prey Availability
Relative Detection Range
Detection Threshold Increase (dB)
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
0
3
6
9
12
15
18
21
24
27
30
33
36
39
42
45
48
51
54
57
60
Relative Detection Range
planar-parallel model
planar-perpendicular model
volumetric model

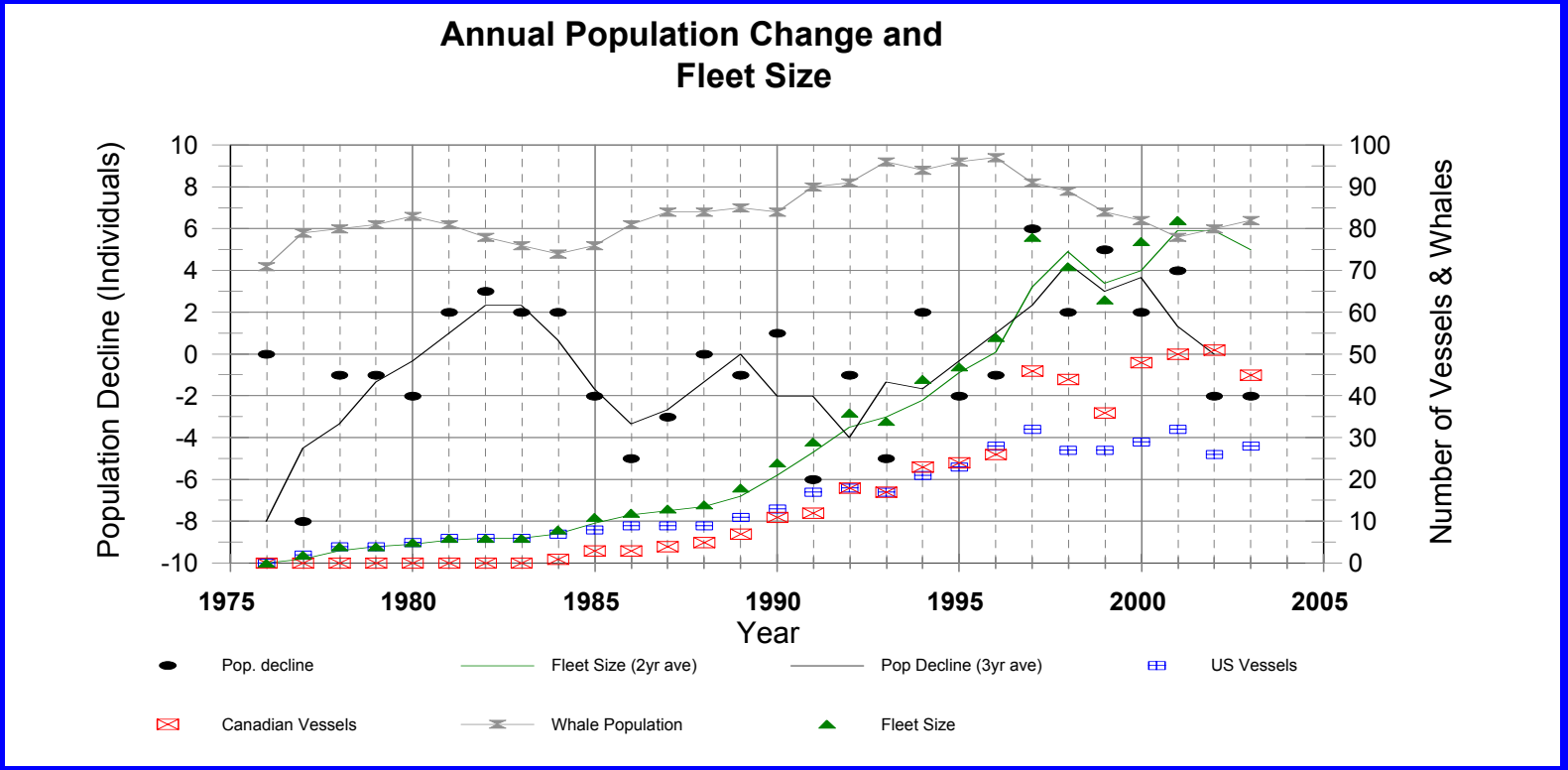
Effects of Population Size and Cumulative Effect Size on Population Growth



- **negligible effects expected well below carrying capacity**
- **disturbance costly near carrying capacity**

Bain *et al.* (submitted)

Correlation (r^2=0.42, p < .01) of Fleet Size with Population Dynamics



- **Role in Decline**
  - Could account for much of recent decline in Southern Residents
- **Role in Recovery**
  - Toxins would slow recovery in Southern Residents
  - Recovery of fish stocks could offset effects of whale watching

(Bain et al.)

Reducing the Cumulative Effect of Whale Watching

- Total Quota Based on Potential Biological Removal
- Limited Entry/Individual Transferable Quotas
- License Fee to Cover Management Costs
- Time and area closures
- Changing operating practices to reduce impact
  - Quieter Vessels
  - Increasing Viewing Distance
  - Slowing Down Near Whales

Thanks to colleagues

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Minerals Management Service
Orca Free
Orca Conservancy
Orca Relief Citizens Alliance
Friday Harbor Laboratories
Whale Watch Operators Association NW
NSERC
Shell
MEC
Weber Fund
WDCS
TRFF
IFAW
Bion
BC Parks
DFO